A ventilative cooling system in a School Building, Imola, Italy

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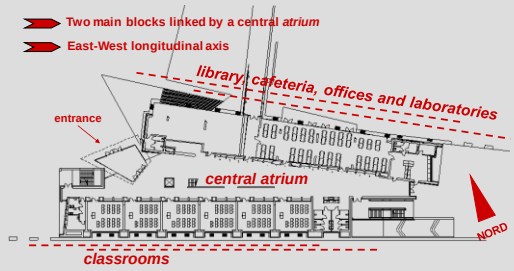
Building layout

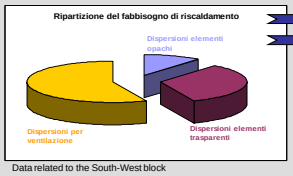
- Two main blocks linked by a central *atrium*
- East-West longitudinal axis



Estimate of energy needs

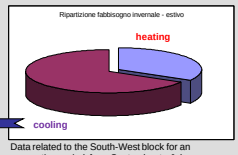
PRELIMINARY - PHASE 1

- Focussed simulations of energy strategies and comparison to a benchmark configuration
- Calculation of annual energy needs using simplified tools



Data related to the South-West block

- attention to ventilation load
- need to high-performance glazing



Data related to the South-West block for an occupation period from September to July

priority to application of passive cooling systems

Estimate of energy needs

PRELIMINARY - PHASE 2

- Evaluation of energ-saving benefit related to alternative strategies

	BLOCCO AULE S-O	Fabbisogno di energia [KWh/m² anno]	
		RISCALDAMENTO	RAFFRESCAMENTO
A	SIMULAZIONE - A - ventilazione minima - struttura leggera	13.6	-89.7
B	SIMULAZIONE - B - ventilazione extra - struttura leggera	13.6	-31.9
C	SIMULAZIONE - C - ventilazione minima - struttura medio - pesante	21.1	-41.4
D	SIMULAZIONE - D - ventilazione extra - struttura medio - pesante	21.1	-0.8

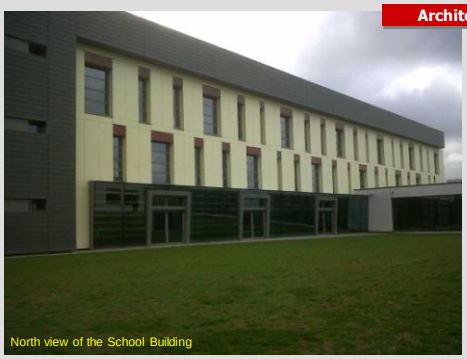
SOLUTION D
to optimise yearly energy balance

TECHNOLOGICAL OPTIONS FOR INDOOR CLIMATE CONTROL SYSTEMS

Architecture

South view of the School Building

Architecture

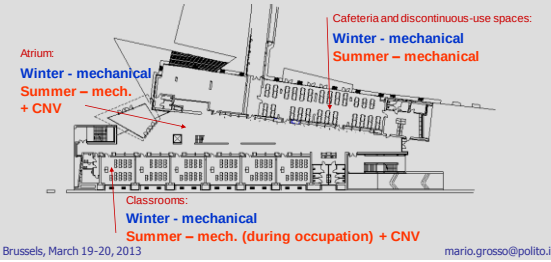


North view of the School Building

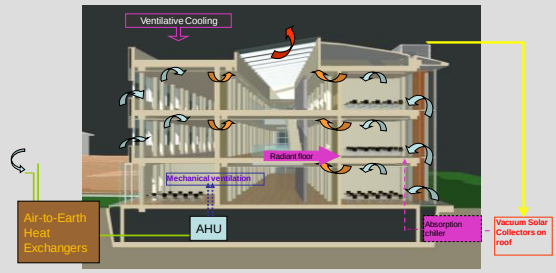
Ventilation system

Hybrid system (controlled natural/mechanical system)

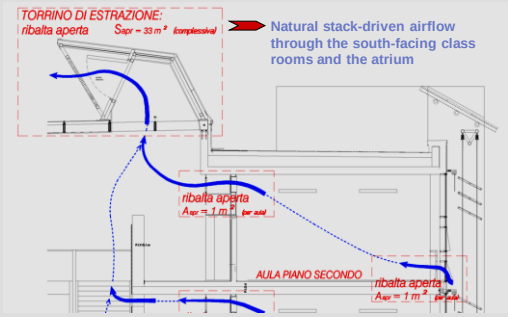
Controlled natural ventilation (CNV): motorised sensor-driven openings related to IAQ and thermal comfort



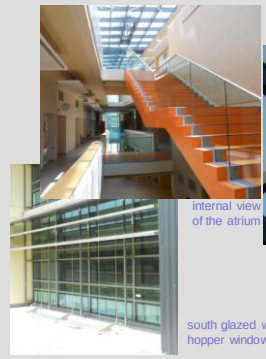
Cooling systems



Ventilative cooling



Ventilative cooling



internal view of the atrium

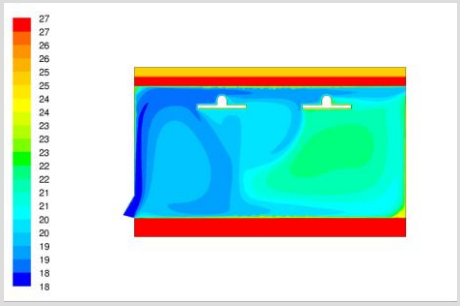
vented clerestory on the atrium glazed roof

south glazed wall with hopper window openings

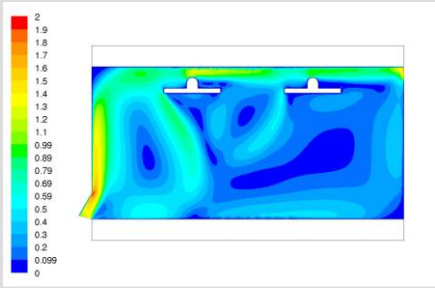
Isolated suspended-ceiling element integrating lighting, sound adsorption, and air diffusion

Isolated suspended-ceiling element integrating lighting, sound adsorption, and air diffusion: laboratory testing of air downdraft distribution

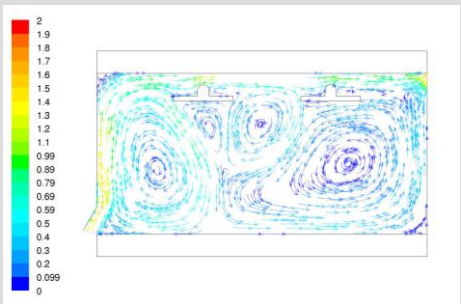
2-D CFD simulation in a classroom with ceiling appliances:
air temperature zones after 1 hour with a gradient of 10 °C



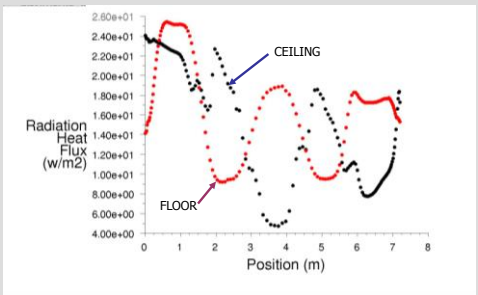
2-D CFD simulation in a classroom with ceiling appliances:
air velocity zones after 1 hour with a gradient of 10 °C



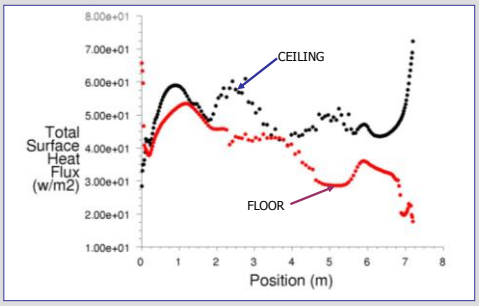
2-D CFD simulation in a classroom with ceiling appliances:
air velocity contour lines after 1 hour



2-D CFD simulation in a classroom with ceiling appliances:
radiation heat flux after 1 h as a function of distance from inlet opening

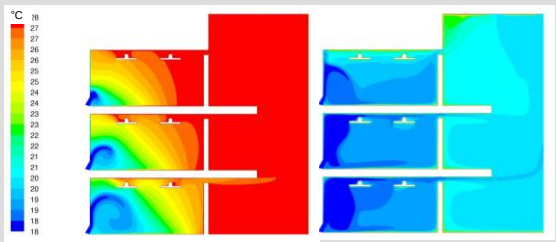


2-D CFD simulation in a classroom with ceiling appliances:
total surface heat flux after 1 h as a function of distance from inlet opening

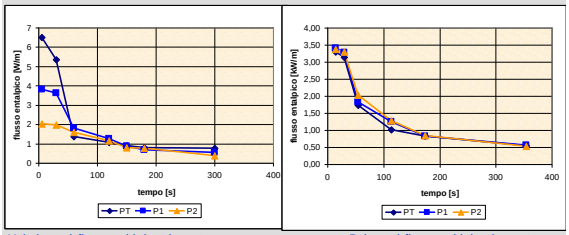


Ventilative cooling

2D CFD simulation of flows between classrooms at the different storeys and the atrium: *temperature zones for a gradient of 10 °C between inside (atrium) and outside*



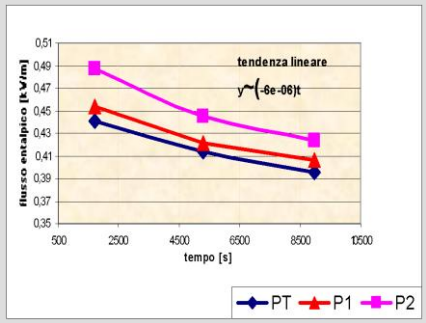
2-D CFD simulations: *enthalpic flows for the three storeys in the time interval 0÷400 s*



Unbalanced flows amid the trhee storeys

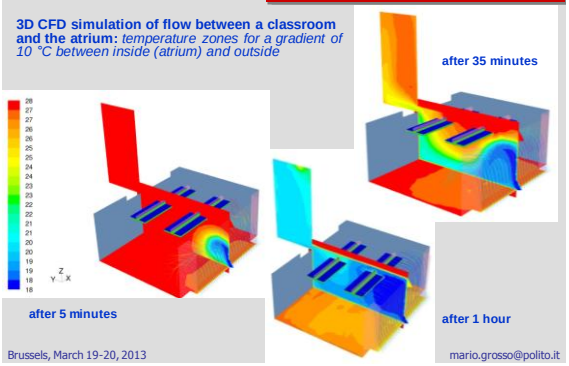
Balanced flows amid the three storeys

2-D CFD simulations: *enthalpic flows for the three storeys in the time interval 500÷10500 s (linear trend)*

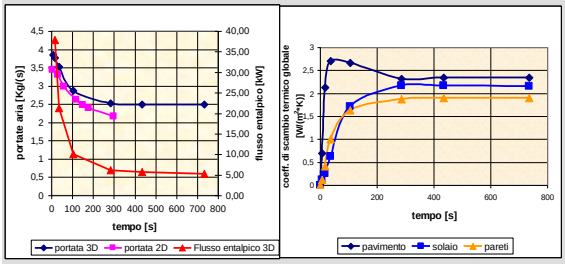


Night cooling of thermal mass

3D CFD simulation of flow between a classroom and the atrium: *temperature zones for a gradient of 10 °C between inside (atrium) and outside*



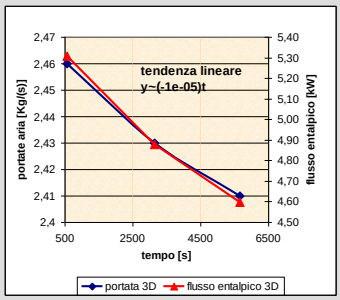
3-D CFD simulations: *airflow rates, enthalpic flow and global thermal exchange coefficient in the time interval 0÷800 s*



3-D airflow rate, 2-D airflow rate, 3-D enthalpic flow

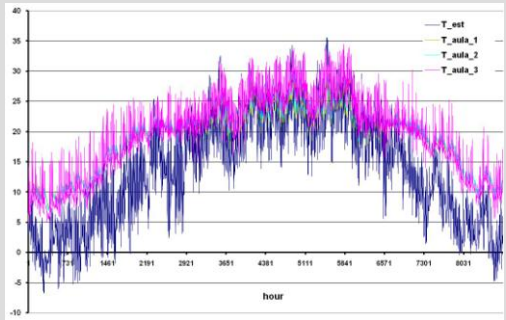
global thermal exchange coefficient for floor, ceiling, walls

3-D CFD simulations: *airflow rate and enthalpic flow in the time interval 500÷6500 s (linear trend)*

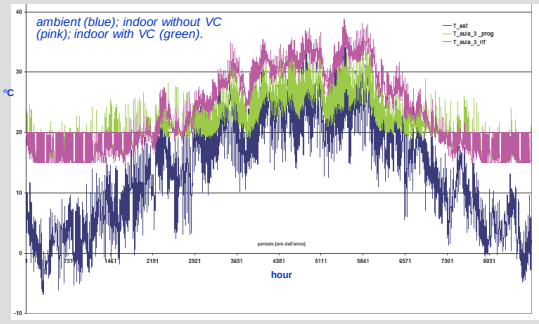


3-D airflow rate, 3-D enthalpic flow

Thermal dynamic simulations using TRNSYS: *annual indoor air temperature profile in the south- facing classrooms with ventilative cooling*



Thermal dynamic simulations using TRNSYS: *annual indoor air temperature profile in the 3° storey south- facing classroom*



International Workshop: Ventilative Cooling
Need, Challenges and Solution Examples

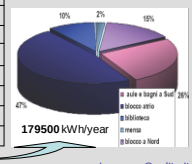
Contribution to energy saving of RES & RUE technologies (prediction)

Technology	Annual energy intensity [kWh/m²-gfa] heating	cooling
Reference configuration (a)	79.5	22.4
Reference configuration (b)	141.0	38.3
High insulation (opaque components)	72.7	25.1
High insulation (glazed components)	66.2	28.6
Time optimisation of mechanical ventilation (OMV)	64.9	15.4
Shading devices (fixed)	84.0	15.8
Shading devices (fixed and movable)	86.8	14.0
Total of envelope technologies (ET)	67.0	20.1
ET+ OMV + heat recovery	44.3	13.4
ET+ OMV + Solarwall®	42.5	13.4
ET+ OMV + VC	54.1	6.6
TOTAL	37.4	6.6

U_{value} (walls) = **0,45** W/m²K
U_{value} (glazing) = **2,65** W/m²K
Mech. Vent. for 12 h/day

As configuration (a) with Mech. Vent. for 24 h/day

U_{value} (walls) = **0,30** W/m²K
U_{value} (glazing) = **1,57** W/m²K



179500 kWh/year

Brussels, March 19-20, 2013 mario.grosso@polito.it